

Article

Disentangling Fuzzy Weighting and Fuzzy Ranking in AHP–TOPSIS: A Comparative Study of PV Self-Consumption Planning for Agricultural Pumping

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Abstract

The transition toward renewable energy in agricultural pumping requires robust decision-making tools capable of addressing multiple, often conflicting criteria. This study investigates the respective contributions of fuzzy weighting and fuzzy ranking within AHP–TOPSIS frameworks for photovoltaic (PV) self-consumption planning in agricultural pumping applications. Unlike conventional MCDM applications that focus on identifying a preferred alternative using a single classical or fuzzy formulation, this study systematically isolates the effects of fuzziness at the weighting and ranking stages. Four methodological configurations are comparatively analyzed: classical AHP–TOPSIS, fuzzy AHP–TOPSIS with fuzzy weighting, AHP–TOPSIS with fuzzy ranking, and a fully fuzzy AHP–TOPSIS approach incorporating both fuzzy weighting and fuzzy ranking. Triangular fuzzy numbers are employed to represent the vagueness and subjectivity inherent in expert judgments, which are commonly expressed using quantitative scales despite their imprecise nature. A real-world case study involving the planning of a self-consumption PV installation for an agricultural pumping system in southeastern Spain is used to assess and compare the four approaches. The results distinguish the effects of fuzzy weighting and fuzzy ranking on both criteria weights and alternative rankings, showing whether the differences between classical and fuzzy formulations arise primarily from the weighting stage, the ranking stage, or their combined application. Rather than assuming that fuzzy formulations provide universally superior results, the analysis identifies the specific circumstances and stages in which fuzzy modelling produces meaningful changes in the decision outcome. The findings contribute to sustainable energy planning by providing a systematic framework for PV self-consumption planning in agricultural pumping under uncertain and subjective decision environments.



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1. Introduction

The global energy landscape is undergoing a profound transformation driven by the need to reduce greenhouse gas emissions, enhance energy security, and mitigate the environmental impacts associated with fossil fuel dependence [1]. Within this context, renewable energy technologies—particularly solar photovoltaic (PV) and wind energy—have